DOCUMENT RESUME

ED 089 997 SE 017 550

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TITLE Affective Variables and Sex Differences in Mathematical Abilities.
PUB DATE Apr 74
NOTE 11p.; Paper presented at the annual meeting of the American Educational Research Association (Chicago, Illinois, April 1974)

EDRS PRICE MF-$0.75 HC-$1.50 PLUS POSTAGE
DESCRIPTORS *Achievement; *Mathematics Education; Personality Theories; *Research; Research Reviews (Publications); *Sex Differences; *Student Attitudes; Student Characteristics

ABSTRACT

This article discusses the literature on sex differences in mathematics achievement and advances four possible explanations to account for the differences. Attitude and other affective dimensions are considered as learned response tendencies which interact with ability. Results of correlational, multiple regression, and factor analyses on data from one group of college students using attitude and aptitude scores are reported and discussed. (LS)

Session No. 5.06 at 1974 AERA annual convention

AFFECTIVE VARIABLES AND SEX DIFFERENCES IN MATHEMATICAL ABILITIES

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The notion that boys and men are better in mathematics than girls and women, speaking both historically and contemporaneously, has received attention in various sources. Looking at the matter historically, Hypatia was apparently the only woman mathematician of importance prior to the 18th century. Since then there have been Maria Agnesi, Sophie Germain, Sonja Kovalevsky, Emmy Noether, and perhaps a few others--but very few compared to the number of men who have achieved eminence in mathematics during the same period (Iacobacci, 1970). On the more mundane educational scene, the typical finding in the elementary school is that girls are at least equal and sometimes better than boys in mathematics achievement. But in junior high school boys begin to creep ahead of girls, the superiority of boys after grade seven being revealed particularly on problem-solving tasks such as those on arithmetic reasoning tests (see Hilton, 1970; Jacobs, 1973; Jarvis, 1964; Powell, O'Connor & Parsley, 1964). In addition, there is evidence that the factor structure of mathematical ability becomes more differentiated with maturity. This "age differentiation" becomes especially manifested in high school, where boys show a greater number and more sharply differentiated mathematical abilities than girls.

Hypotheses Concerning Sex Differences

It is debatable whether these findings are the causes or the effects of the popular conception that mathematics is primarily a masculine enterprise. In any event, at least four explanations have been proposed to account for sex differences in mathematical abilities: the masculine-identification hypothesis, the differential social reinforcement hypothesis, the same-sex role modeling hypothesis, and the sex-linked recessive gene hypothesis. To consider the last explanation first, Stafford (1972) proposed that sex differences in numerical and spatial abilities are due, at least in part, to the fact that these abilities--like pattern baldness, hemophilia, and red-green color blindness--are transmitted by sex-linked, recessive genes. If this hypothesis is correct, then a person's mathematical ability should be more closely related to that of the opposite-sex parent than to that of the same-sex parent. Although this is a compelling and timely hypothesis, it has encountered certain difficulties (see Garron, 1970). Furthermore, even Stafford does not argue that genetics completely explains sex differences in mathematical abilities.

A second explanation--the masculine-identification hypothesis of Plank and Plank (1954)--maintains that since working mathematics is an aggressive, masculine occupation, both boys and girls who are good at it identify more closely with their fathers or other strong male figures. The implication is that women mathematicians are consequently more masculine than women non-mathematicians. Cited in support of the masculine-identification hypothesis are studies relating father absence to ability in mathematics (Carlsmith, 1964; Landy, Rosenberg, & Sutton-Smith, 1969). However, the notion that a masculine interest pattern and a higher level of aggression are associated with proficiency in mathematics has failed to receive substantial empirical support. At least it is clear from the evidence that women mathematics majors are not necessarily aggressive or "masculine."

A third hypothesis, related to the first one, is that sex differences in mathematical ability are due to same-sex role modeling (Maccoby, 1966; Bem & Bem, 1970; Milton, 1958). According to this explanation, since mothers are typically more verbally oriented and fathers more quantitatively oriented, young girls who model their behavior after mother come to view themselves as incompetent in mathematics. A fourth hypothesis maintains that sex differences in quantitative ability are produced by differential social reinforcement. Quite simply, this hypothesis states that since boys usually receive more positive social reinforcement for mathematical endeavors than girls, they come to be better at it and to like it better.

Some research, most of it not very well designed, has been conducted to test the differential social reinforcement and same-sex role modeling hypotheses and to find ways to improve girls' abilities in mathematical problem solving. Two conclusions stemming from this research are that (a) improving their attitudes toward mathematics seems to help girls do better in the subject and (b) casting mathematical problems in terms of "typical feminine interest" content improves girls' scores on those problems (Carey, 1958; Milton, 1958; Graf & Riddell, 1972).

Personal Research

It may seem inappropriate that so far I have scarcely mentioned attitudes and other affective variables. After all, this part of the program was supposed to be concerned with "Affective Variables, etc." The reason why I have neglected affective variables is because I do not view affect and cognition as separate dimensions, but as integral components of personality. Thus, the relationship between attitude or interest and performance is reciprocal and dynamic, in that attitude or interest affects achievement and achievement in turn affects attitude and interest. In other words, greater achievement results from an improved attitude and an improved attitude results from greater achievement.

Although theoretical controversy may be good for stimulating research, it can lead to channelized perception and professional myopia. In keeping with a more dynamic explanation of both attitude toward mathematics and ability in this subject, it is proposed that both specific attitudes and specific abilities are learned response tendencies shaped by sociocultural experiences impressed on a more general, genetically-determined temperamental and ability substrate (Aiken, 1972). This composite interpretation views the several components of mathematical ability as acquired differentiations of general cognitive ability, such differentiation being the consequence of a specific reinforcement history, modeling the behavior of significant others, and positive transfer of skills from one mathematical task to another. Attitude and other affective dimensions which interact with ability to influence proficiency in mathematics are also conceptualized as learned response tendencies. Such a dynamic, interactive explanation has been the guiding principle of my research on psychological factors in learning mathematics.

This research, which has been concerned primarily with junior-high, high school, and college students, has involved correlational, multiple regression, and factor analyses of scores on a wide range of affective and cognitive variables. Some representative results are shown in the correlation matrix of Table 1 and the factor matrix of Table 2. Table 1, which is based on a study of 111 college sophomore men and 128 college sophomore women, contains the correlations among 10 Adjective Checklist scores, Scholastic Aptitude Test-Mathematical score, and score on the Mathematics Attitude Scale. These results indicate that, in both men and women, attitude toward mathematics is positively related to self-control, personal adjustment, need for achievement, need for endurance, and need for order; mathematics attitude is negatively related to emotional lability and need for aggression. Not only do these findings contradict the theory that attitude toward mathematics is related to masculine aggression, but they suggest that it is associated with a cluster of traits which would clearly be useful to a mathematical problem solver: self-control, emotional stability, good personal adjustment, high need for achievement, endurance, and orderliness.

Table 2 contains the results of two orthogonal powered-vector factor analyses--one for 72 eighth-grade girls and a second for 84 eighth-grade boys--based on five ability measures, score on the Mathematics Attitude Scale, and scores on 16 items of a specially designed biographical inventory. Two independent factors were obtained for girls and one factor for boys. Factor A in both cases is interpreted as "Student's Mathematical Ability," and Factor B for girls is "Father's Reported Mathematical Ability.". Note that since Factors A and B are orthogonal, it may be concluded that for the females "Student's Mathematical Ability" was independent of their "Father's Reported Mathematical Ability." In contrast, for males "Student's Mathematical Ability" was positively related to "Father's Reported Mathematical Ability." These findings are clearly inconsistent with both the "masculine identification" and "sex-linked recessive gene" hypothesis.

Finally, it can be seen from Table 2 that mathematical ability in these junior-high school girls is more closely related to their attitudes toward mathematics than in the boys. Behr (personal communication) and others have reported similar findings, in addition to the fact that mathematical ability test scores and mathematics grades are more closely related in girls than in boys. Although there is some variation in predictability with age, using both affective and cognitive variables we are usually able to do a better job of forecasting the school mathematics grades of females than those of males. Consequently, another noteworthy sex difference--seemingly the opposite of the traditional stereotype--emerges from these studies. Women, at least on psychological and educational measures, are apparently more predictable than men!

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Table 1

Correlations Among Adjective Checklist, Mathematics Attitude Scale, and SAT-Mathematical Scores (12)

Variable	Sex	2	3	4	5	6	7	8	9	10	11	12
		Correlations										
1. ACL Deference (Female)	M	.62	.02	.65	.35	.57	.54	-.31	-.49	-.16	.15	-.02
	F	.44	-.05	.64	.52	.54	.41	-.21	-.41	-.52	.17	.16
2. ACL Self Control	M		-.36	.45	.37	.63	.66	-.49	-.59	.08	.14	.09
	F		-.50	.70	.37	.72	.75	-.54	-.70	.20	.25	.20
3. ACL Lability	M			-.20	-.12	-.34	-.41	-.04	.08	-.27	-.25	-.11
	F			-.23	-.16	-.46	-.58	.29	.27	-.42	-.17	-.10
4. ACL Personal Adjustment	M				.34	.51	.42	-.35	-.44	-.05	.20	.03
	F				.39	.59	.62	-.45	-.63	-.14	.25	.22
5. ACL Need for Achievement	M					.76	.56	-.06	.05	-.33	.14	.03
	F					.73	.56	.07	-.02	-.48	.28	.07
6. ACL Need for Endurance	M						.85	-.18	-.20	-.13	.21	.03
	F						.88	-.20	-.38	-.18	.27	.12
7. ACL Need for Order	M							-.21	-.26	-.02	.21	.08
	F							-.28	-.37	.01	.22	.13
8. ACL Need for Autonomy	M								.66	-.09	-.06	.06
	F								.68	-.32	-.18	-.11
9. ACL Need for Aggression	M									-.24	-.17	-.08
	F									-.24	-.20	-.09
10. ACL Counseling Readiness	M										.21	.25
	F										.00	.04
11. Mathematics Attitude	M											.53
	F											.54

Table 2

Factor Analyses of Eighth Grade Data

Variable	Girls (N=72) Factor A	Girls (N=72) Factor B	Boys(N=84) Factor A
Eighth-grade final math mark	.791	-.025	.745
CTMM Language I.Q.	.826	.001	.773
CTMM Nonlanguage I.Q.	.774	.015	.728
CAT Arithmetic Reasoning	.922	.003	.897
CAT Arithmetic Fundamentals	.875	-.027	.862
Mathematics Attitude	.378	.061	.268
"My father and I have always been very close to each other."	.085	.092	.012
"I have an older brother who likes mathematics."	-.039	.164	-.330
"I have an older brother."	-.091	.013	-.337
"I have a younger sister."	.130	.058	-.030
"I have a younger sister who likes arithmetic."	.069	-.091	-.221
"My father graduated from high school."	.207	.270	.428
"My mathematics teachers in school have usually been somewhat impatient and demanding."	-.423	.030	-.285
"My father uses mathematics on his job."	.192	.146	.177

Table 2 (cont'd)

"My mother graduated from high school."	.396	.331	.385
"I have usually been an excellent student in school."	.169	-.114	.300
"My father made high grades in mathematics when he was in school."	.034	.828	.262
"In elementary school, my grades in arithmetic were usually high."	-.027	.122	.343
"My father is a professional man (doctor, lawyer, engineer, teacher, etc.)."	.299	.089	.393
"My mother made high grades in mathematics when she was in school."	.073	.154	.108
"My father likes mathematics."	.126	.822	.309
"I usually stick to a job until it is finished."	.088	-.110	.156